Research Article

The Impact on People's Well-being of Utilizing Greenery in the Design of High-rise Residential Building Balconies

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The topic of well-being in the built environment has garnered substantial attention in recent years. Particularly during the COVID-19 pandemic, when people were confined indoors and had limited access to nature, the importance of spaces allowing some level of outdoor interaction was more recognized. This study aims to investigate the potential impact of incorporating vegetation in the design of high-rise residential building balconies on well-being. Immersive Virtual Reality Environment (IVRE) was utilized, and an experiment was conducted with 45 participants. Participants were randomly assigned to one of the three distinct groups, each group consisted of two different VR environments. The balcony with no vegetation was kept the same in all three groups. The second environment was one of the three version of the balcony with certain volume of greenery added to its design (Low-Medium-High). Participants were then interviewed based on a standard questionnaire assessing well-being in the built environment. The questions aimed at determining which balcony design was more effective in enhancing well-being.

The results indicate that greenery on the balcony has the potential to influence people's well-being. The findings indicated that balconies featuring greenery demonstrated significant impact on individuals' well-being. In such environments, individuals reported increased happiness, satisfaction, a sense of connection to others, greater independence, and an improved ability to accomplish tasks successfully, ultimately contributing to improved mental health. Further analysis demonstrated that the volume of greenery on the balcony does not significantly impact well-being. In other words, well-being can be enhanced even with a small amount of greenery, such as a few potted plants. Moreover, the results revealed that the reported positive impacts were not significantly moderated by participants' differences in age and gender.

1. *Introduction*

The issue of well-being in the built environment has received considerable attention in recent years. Increase in the Population and the spikes in the housing prices and land values in the urban areas, especially in big cities, have led to high density developments, which has caused many problems over the years (Behrad & Bahrami, 2015; Saedi, 2020). Among many problems, exposure to bad conditions of a built environment has shown to be related to adverse effects on mental health (Núñez-González et al., 2020; Saedi & Rice 2021). An inappropriate physical condition in buildings is associated with increased risk of stress which leads to mental disorders and depression (Zarghami & Fatourehchi, 2018; Han & Kim, 2019).

There are two sides to mental health. The first aspect is called negative mental health, which includes mental disorders and second is called positive mental health, which includes optimal functioning and general well-being. Despite their correlation, these two aspects are different.(Deci & Ryan, 2008; Keyes, Shmotkin, & Ryff, 2002). Evidence supports the fact that high well-being has beneficial points for general health, longevity, productivity and social relationships(Yun, Rhee, Kang, & Sim, 2019). Well-being, which is given a lot of attention nowadays, is divided into objective (Eudemonic) and subjective (Hedonic) groups(Schönfeld, Brailovskaia, Bieda, Zhang, & Margraf, 2016).

Subjective well-being includes life satisfaction, positive emotions, and the absence of negative emotions, and objective well-being relates to individuals' goals and their ability to perform properly in line with those goals.(Tennant et al., 2007). Previous studies have agreed that subjective well-being is a broad topic that refers to evaluations of the quality of life and includes both affective and cognitive aspects (Diener, Suh, Lucas, & Smith, 1999). Increased subjective well-being correlated with improved sleep quality and decreased blood pressure, so it can be said that subjective well-being affects physical health, mental health, reduces the risk of death and increase better social relations. Consequently, well-being plays an important role in quality of life(Saputra & Tentama, 2020). Subjective well-being also has an impact on how individuals perceive their profession. A number of studies show that higher subjective well-being can increase higher income, and increase productivity and reduce mental fatigue or work-related stress. The data suggests that people's satisfaction with the residential setting in housing is dependent, at least in part, on the effective use of the open spaces nearby one's residential building (Abu-Ghazzeh, 1999) and affects their social interaction.

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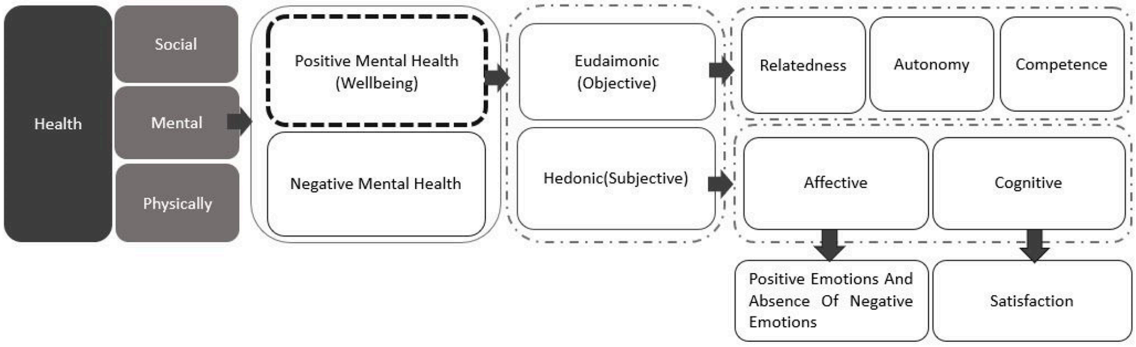

Figure 1. *Mental Health Subsets*

Previous studies have shown that many factors can affect mental health and well-being. Research findings have revealed that people with the most access to nature have higher degree of well-being (Anders, Hooley, & Kivlighan III, 2023) Moreover, the landscape has received enough attention as a continuum between wild nature and designed environment such as urban and rural forests, green spaces, parks, gardens, waters, and neighborhood areas(Abraham, Sommerhalder, & Abel, 2010). Numerous Studies have demonstrated that the presence of large green spaces can notably moderate temperature (Yu, Zhang, Fukuda, & Ma, 2023). Other studies have underscored the importance of green spaces within and near neighborhoods which can help to cope with public health emergencies (Guo et al., 2022). During covid19 most governments issued stay-at-home orders for an extended period of time. Limited access to outdoor spaces resulted in serious problems like depression, insomnia, stress, and other mental illness (Dzhambov et al., 2021). The significance of balconies has become more apparent, especially in the context of the COVID-19 pandemic, which has underscored the importance of private spaces like balconies. They offer an opportunity for fresh air, natural light, and a sense of community interaction, addressing the limitations experienced with public spaces during the pandemic. In addition, in contrast to outdoor and indoor spaces, there is far less information about the effect of semi-open spaces, especially balconies, on mental health (Omrani, Garcia-Hansen, Capra, & Drogemuller, 2017).

Therefore, this study has three key aims. First, to explore the potential role that balconies' design can play to contribute to people's well-being. Second, to examine whether or not the placement of greenery on balconies can affect residents' well-being. Finally, to investigate if a difference in the greenery's volume utilized in balconies' design can impact individual's well-being at different levels. As studies such as (Saedi & Boone, 2018; Saedi et al., 2021; Mahtani et al., 2022) suggested utilizing virtual reality environments allows researchers to modify the experiments' site more cost effectively and in a timely fashion. Therefore, this study utilizes immersive virtual reality environments (IVRE) which also allows for mitigating potential accessibility challenges commonly encountered with physical spaces (Saedi & Rice, 2022a; Saedi & Rice 2022b).

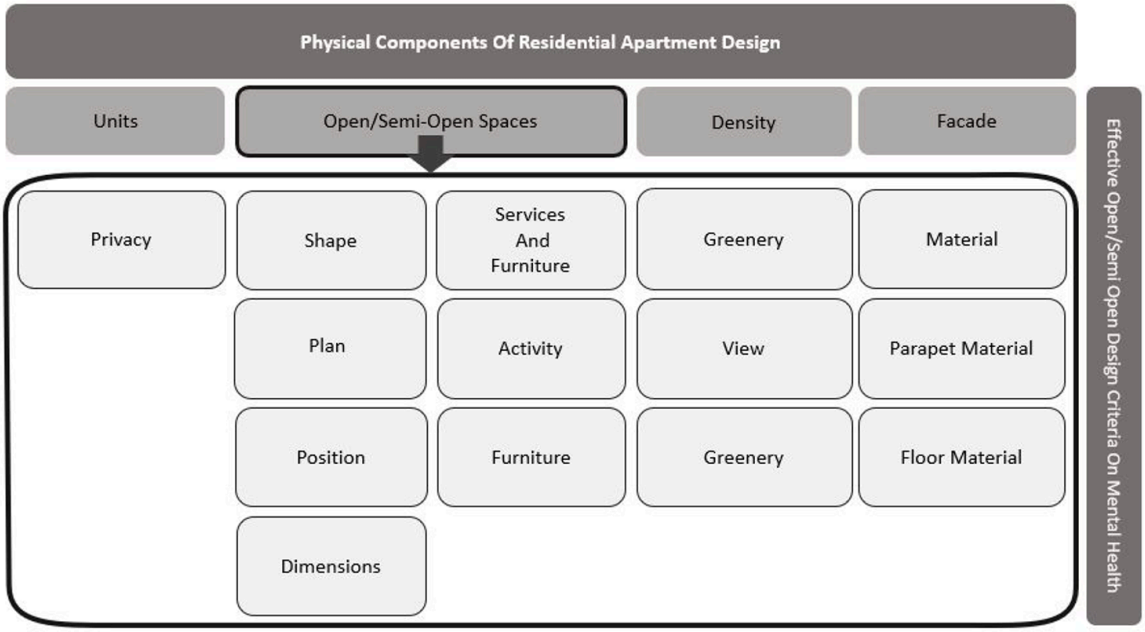

Figure 2. *Physical Factors Of Apartment Design*

2. *Method*

2.1. Research process

This research is a quantitative exploratory experiment that aims to evaluate the impact of using greenery in the balcony design on users' well-being. Following the same process as developed by Saedi (2020), and implement in further studies in 2022 by Saedi and Rice, in this research, participants were randomly entered into the VR scenario separately to test the effect of greenery in balcony environments on human well-being. We randomly divided people into three groups (group A/B, group A/C and group A/D), and in each group participants only experienced two out of the four environments, one of which in all group was kept constant. There are two reasons for this between-subject design. Firstly, to minimize the carry over effect. Secondly, to reduce the negative effects of using the VR gear on the participants, such as headache. Data was collected through the "Building Well-being scale" questionnaire filled by the participants (Watson, 2018). For each group, participants experienced the environments while sitting on a chair and were free to explore all 360-degrees of each environment.

Participants experienced the two versions of the balcony on the OCULUS QUEST 1 at a resolution of 1440 × 1600 pixels, and 110◦ field of view (FOV). Each participant had to answer the questions while being immersed in the VR environment. This included providing basic personal information and checking for VR related simulator sickness symptoms before the actual experiment. The experiment took place in a room with no natural light and opening to the outdoor environment with controlled air conditioning to keep the study environment as similar as possible for all participants. The room contained the VR headset and a desk for the researcher conducting the experiment. Participants practiced with the VR headset and were given instructions on how to engage with the VR environment and how to fill out the questionnaires during a trial round and before their data being recorded. Individuals were asked to stay within the one meter by one-meter square that was marked on the floor during the experiment. This zone was covered by the VR spatial location sensors communicating with the VR headset. Finally, data analysis was conducted by statistical product and service solutions (SPSS).

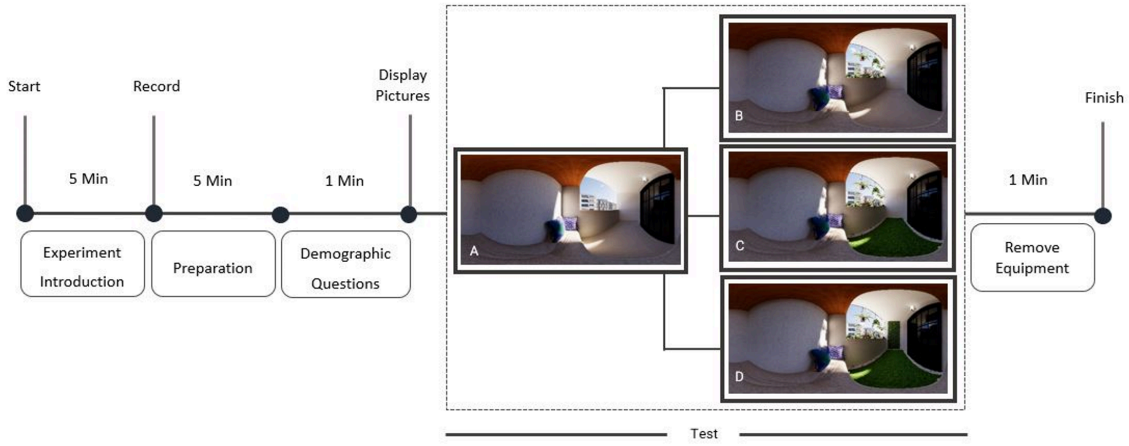

Figure 3. *Overview Of The Experiment Procedure.*

2.2. *Research tools*

2.2.1. *Virtual reality*

For many years, researchers employed a variety of tools and techniques to comprehend the human experience including visualization methods such as still images, which fall short to provide participants with an experience closer to the real-life situations in order to evaluate an environment accurately (Saedi, 2020; Saedi & Rice, 2022a; Asl et al., 2022; Gill et al., 2023). This study used VR technology, which has shown enormous potential in evaluating the restorative quality of different environments. In addition, previous research has also shown that human psychological perception and physiological reactions are similar in VR and real-life scenarios. Existing research found participants' subjective and objective visual responses are similar to the real and virtual environment(Abd-Alhamid, Kent, Bennett, Calautit, & Wu, 2019).The three conditions of immersion, interaction and imagination can be provided by VR (Bhagavathula, Williams, Owens, & Gibbons, 2018; Li, Huang, & White, 2022). Moreover, the experience of walking in or around a structure that does not exist can be enhanced by VR. Also, virtual reality technology helps to eliminate some of the mediating variables such as auditory, olfactory system, and interaction with surrounding people that could impact the results of the experiment(Bakr, El Sayad, & Thomas, 2018; Saedi & Rice, 2019).

2.2.2. *Questionnaire*

The questionnaire was based on previous studies by Kelly J Watson, which introduced a novel well-being evaluation approach consisting of a multi-item scale to measure and quantify the well-being outcomes of the building users(Watson, 2018).The building well-being scale is made out of five components: Satisfaction, Affect, Relatedness, Autonomy and Competence. It was developed in reference to two existing, academically developed and validated, multi - item scales for measuring well-being in individuals or groups, not in relation to the built environment. The first scale is the Warwick - Edinburgh Mental Well-being Scale (WEMWBS), and the second is the Questionnaire for Eudaimonic Well-Being (QEWB). The final Building Well-being scale, a combination of two questionnaires mentioned, represents an accessible and effective method to quantify the well-being experienced by the users of a built environment, including well-being scores for each individual user, an overall well-being score for the building, and a score for each measure of well-being. In this study, the participants were asked orally to the present research tests 'the well-being scale in the built environment' questionnaire in a residential building balcony setting. Participants were also asked demographic questions, such as their age, gender, marital status and their education.

Variable	Statements	Questionnaire	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Affect	I feel optimistic when I'm in this building.	WEMWBS	-2	-1	0	1	2
Satisfaction	I have purpose when I'm in this building.	QEWB	-2	-1	0	1	2
Affect	I feel at ease when I'm in this building.	WEMWBS	-2	-1	0	1	2
Relatedness	I feel interested in other people when I'm in this building.	WEMWBS	-2	-1	0	1	2
Autonomy	I can be myself well when I'm in this building.	QEWB	-2	-1	0	1	2
Competence	I deal with problems well when I'm in this building.	WEMWBS	-2	-1	0	1	2
Competence	I think clearly when I'm in this building.	WEMWBS	-2	-1	0	1	2
Satisfaction	I feel useful when I'm in this building.	WEMWBS	-2	-1	0	1	2
Relatedness	I feel close to other people when I'm in this building.	WEMWBS	-2	-1	0	1	2
Satisfaction	I feel fulfilled when I'm in this building.	QEWB	-2	-1	0	1	2
Autonomy	I can make up my own mind about things when I'm in this building.	WEMWBS	-2	-1	0	1	2
Relatedness	I feel valued when I'm in this building.	WEMWBS	-2	-1	0	1	2
Competence	I can apply myself to what I'm doing when I'm in this building.	QEWB	-2	-1	0	1	2
Autonomy	I feel in control of my own decisions when I'm in this building.	QEWB	-2	-1	0	1	2
Affect	I feel energized when I'm in this building.	WEMWBS	-2	-1	0	1	2

Table 1. *The Building Well-Being Scale*

2.2.3. *Participants*

The sample size, calculated according to a global effect size of 0.96 (Cohen, 1992) with a type error of 0.05 and a power of 0.8 was 36. The random sample of 45 participants was recruited from building users in the city where the experiment took place to ensure that final data set after eliminating possible incomplete data or unsuccessful participations meets the calculated sample size. Participation was voluntary and participants were selected among volunteers between 20 and 60 years old and from those with no visual impairments. The final participants consisted of 21 male and 24 female with mean age of 42.

2.3. *Study Context*

The study contexts for this research were four virtual reality balcony designs created using SKETCHUP and ENSCAPE engine. Figure 4 illustrates these designs, each featuring varying levels of greenery (A= No greenery, B= Low Greenery, C= Medium Greenery, D= High Greenery).

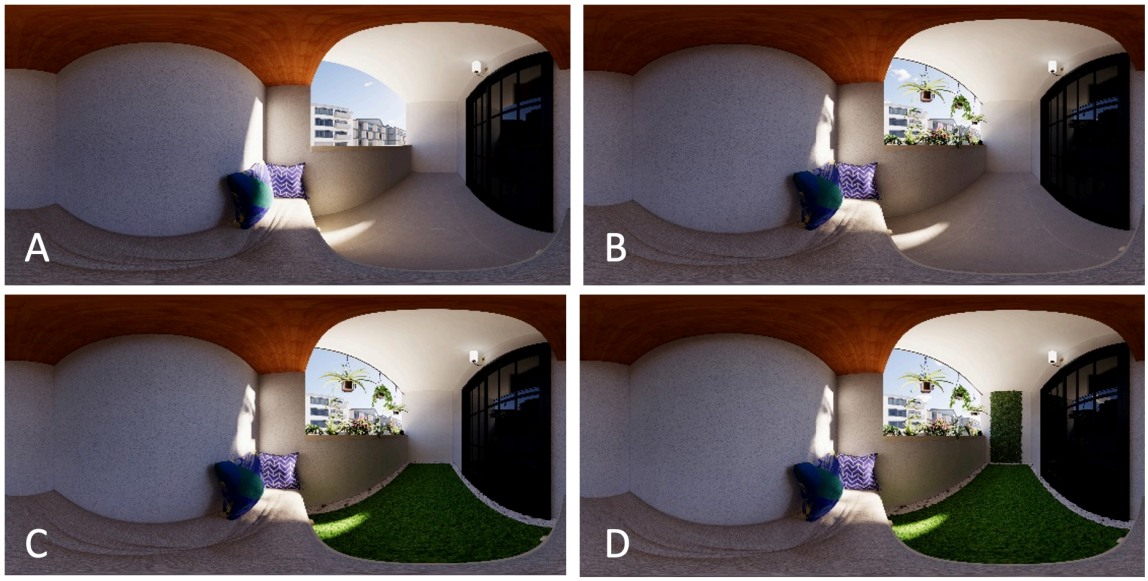

Figure 4. Environment A, B, C and D

3. *Results*

A total of 45 samples were tested and analyzed. The research test was set based on the PLS test. Table1 shows the demographic characteristics of the participants.

		Overall (n=45)	
		n	%
Age(years)	20-40	15	34
	40-60	30	66
Gender	Male	21	47
	Female	24	53
Marital status	Single	15	34
	Married	30	66
Education	Diploma	4	9
	Bachelor degree	20	45
	Master degree	17	37
	Ph.D.	4	9

Table 2. *Characteristics Of The Participants*

Source: The Authors

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To answer the research questions, first, the normality of the research variables was measured, and then the correlation between them was calculated. Table2 shows the descriptive statistics indicators including mean, standard deviation, skewness, kurtosis related to research variables.

IN	WS(EFS)	BG	L Test (F)	SD	M	SK	KU	Picture	Group	Var.
0.16**(0.001)	80.77*(0.65)	2.26**(0.97)	2.38	1.18	2.62	0.32	-0.59	A	A/B	Affect
				0.83	3.91	-0.48	-0.75	B		
				1.02	2.77	- 0.63	-0.61	A	A/C	
				0.48	4.20	0.49	-1.19	C		
				1.33	3.28	-0.52	-0.91	A	A/D	
				0.62	4.51	-1.20	0.69	D		
1.30**(0.05)	82.21*(0.66)	0.79**(0.03)	5.94	1.17	2.91	-0.43	-1.06	A	A/B	Satisfaction
				1.01	3.82	-0.60	-0.57	B		
				0.88	2.77	-0.70	-0.21	A	A/C	
				0.39	4.11	1.07	0.59	C		
				1.18	3.02	-0.23	-1.23	A	A/D	
				0.64	4.42	-0.97	0.13	D		
0.47**(0.02)	62.94*(0.60)	1.32**(0.05)	0.48	1.11	2.88	-0.71	-0.82	A	A/B	Relatedness
				0.82	3.73	-0.19	-0.44	B		
				0.95	2.82	-0.54	-0.65	A	A/C	
				0.65	3.93	-0.71	0.34	C		
				1.29	3.22	-0.52	-0.67	A	A/D	
				0.69	4.33	-0.55	-0.96	D		
0.03**(0.001)	40.38*(0.49)	1.61**(0.07)	2.10	1.04	2.71	0.38	0.32	A	A/B	Autonomy
				0.89	3.35	-0.15	-0.11	B		
				0.94	2.88	-0.35	-0.96	A	A/C	
				0.61	3.60	0.33	0.51	C		
				0.99	3.24	-0.18	-0.74	A	A/D	
				1.00	3.93	-0.39	-1.03	D		
1.87**(0.08)	34.70*(0.45)	3.27**(0.13)	2.09	1.05	3.20	-0.36	0.00	A	A/B	Competence
				0.92	3.57	-0.11	-0.90	B		
				0.87	2.95	-0.99	-0.17	A	A/C	
				0.56	3.86	0.42	-0.38	C		
				0.95	3.64	-0.36	-0.91	A	A/D	
				0.70	4.40	-0.77	-0.50	D		

Table 3. *The Results Of Multivariate Analysis Of Variance And Descriptive Statistics Indicators*

0.001 0.05** Var.: Variables M: Mean SD: Standard L Test(F): Levene's Test BG: Between Group WS: Within Group IN: Interaction*

Nevertheless, the values of skewness and kurtosis of variables are in the range between 1.96 and -1.96 Therefore, the normality of the research variables was in an acceptable range. In this way, parametric tests could be used to analyze the data. The results of multivariate analysis of variance (MANOVA) shows that there is a significant correlation between pictures(environments) in each group. However, no statistical differences between the groups and the environment*group were found. Table4. Provides the results of multivariate analysis of variance.

Partial Eta Squared	SIG.	F	MS	DF	SS	Measure	Source
.097	.117	2.260	3.098	2.000	6.195	Affect	Group
.036	.458	.795	1.048	2.000	2.096	Satisfaction	
.059	.276	1.328	1.911	2.000	3.822	Relatedness	
.071	.211	1.616	2.359	2.000	4.719	Autonomy	
.135	.048	3.274	3.875	2.000	7.751	Competence	
0.65	0.001	80.775	38.678	1.000	38.678	Affect	Environment
0.66	0.001	82.215	33.205	1.000	33.205	Satisfaction	
0.60	0.001	62.941	23.511	1.000	23.511	Relatedness	
0.49	0.001	40.387	10.449	1.000	10.449	Autonomy	
0.45	0.001	34.709	10.449	1.000	10.449	Competence	
.008	0.85	0.16	0.07	2.000	0.15	Affect	Group*Environment
.059	0.28	1.305	0.52	2.000	1.05	Satisfaction	
.022	0.62	0.47	0.17	2.000	0.35	Relatedness	
.002	0.96	0.03	0.00	2.000	0.01	Autonomy	
.082	0.16	1.874	0.56	2.000	1.12	Competence	
			0.47	42.000	20.111	Affect	Error
			0.40	42.000	16.963	Satisfaction	
			0.37	42.000	15.689	Relatedness	
			0.25	42.000	10.867	Autonomy	
			0.30	42.000	12.644	Competence	

Table 4. *The Results Of Multivariate Analysis Of Variance*

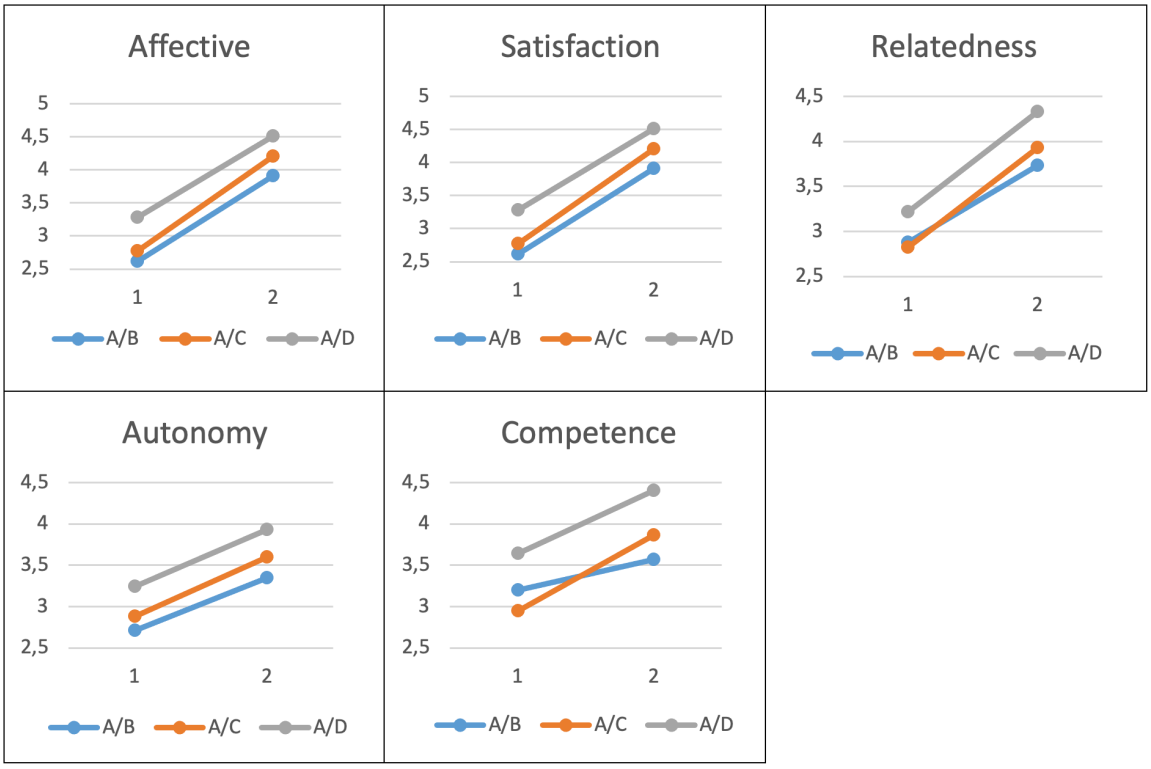

Figure 5. *The Mean Changes Of Each Variable.*

The competence figure is different from others. The reason for this is not clear, but a possible explanation could be that other factors like personal, housing and neighborhood factors are correlated with well-being and its variables (Huebner, Oreszczyn, Direk, & Hamilton, 2022).

Additionally, the results of Table3 show that the significance level of the test for the variance is more than 0.05, so the use of greenery is the same among males and females and also is the same among different age groups.

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Partial Eta Squared	SIG.	F	MS	DF	SS	Measure	Source	
.624	.000	54.796	18.403	1.000	18.403	Affect	Environment	
.651	.000	61.466	20.245	1.000	20.245	Satisfaction		
.527	.000	36.741	11.930	1.000	11.930	Relatedness		
.508	.000	34.089	8.509	1.000	8.509	Autonomy		
.286	.001	13.248	4.295	1.000	4.295	Competence		
.031	.315	1.042	.350	1.000	.350	Affect	Environment*Age	
.011	.552	.361	.119	1.000	.119	Satisfaction		
.000	.905	.014	.005	1.000	.005	Relatedness		
.032	.305	1.087	.271	1.000	.271	Autonomy		
.015	.481	.507	.164	1.000	.164	Competence		
.025	.659	.423	.142	2.000	.284	Affect	Environment*Group	
.134	.092	2.561	.844	2.000	1.687	Satisfaction		
.009	.855	.158	.051	2.000	.102	Relatedness		
.022	.693	.370	.092	2.000	.185	Autonomy		
.036	.548	.612	.199	2.000	.397	Competence		
.010	.572	.326	.110	1.000	.110	Affect	Environment*Gender	
.006	.650	.210	.069	1.000	.069	Satisfaction		
.030	.323	1.007	.327	1.000	.327	Relatedness		
.003	.756	.098	.024	1.000	.024	Autonomy		
.001	.841	.041	.013	1.000	.013	Competence		
.091	.206	1.659	.557	2.000	1.115	Affect	Environment*Age*Group	
.136	.089	2.606	.858	2.000	1.717	Satisfaction		
.047	.449	.819	.266	2.000	.532	Relatedness		
.025	.664	.415	.104	2.000	.207	Autonomy		
.065	.332	1.140	.369	2.000	.739	Competence		
.055	.177	1.905	.640	1.000	.640	Affect	Environment*Age*Gender	
.164	.016	6.480	2.134	1.000	2.134	Satisfaction		
.076	.110	2.700	.877	1.000	.877	Relatedness		
.003	.756	.098	.024	1.000	.024	Autonomy		
.074	.113	2.648	.858	1.000	.858	Competence		
.088	.220	1.584	.532	2.000	1.064	Affect	Environment*Group*Gender	
.045	.468	.778	.256	2.000	.512	Satisfaction		
.054	.401	.938	.305	2.000	.609	Relatedness		
.073	.288	1.292	.322	2.000	.645	Autonomy		
.045	.468	.777	.252	2.000	.504	Competence		
.167	.049	3.306	1.110	2.000	2.221	Affect	Environment*Age*Group*Gender	
.061	.353	1.076	.355	2.000	.709	Satisfaction		
.105	.159	1.945	.632	2.000	1.263	Relatedness		

Partial Eta Squared	SIG.	F	MS	DF	SS	Measure	Source	
.158	.058	3.100	.774	2.000	1.547	Autonomy		
.002	.969	.031	.010	2.000	.020	Competence		
			.336	33.000	11.083	Affect	Error	
			.329	33.000	10.869	Satisfaction		
			.325	33.000	10.715	Relatedness		
			.250	33.000	8.237	Autonomy		
			.324	33.000	10.698	Competence		

Table 5. *The Results Of Multivariate Analysis Of Variance Between Different Age And Gender.*

4. *Discussion*

The aim of the present research was to examine whether adding greenery to the design of a balcony could affect people's well-being. The outcomes suggest that the use of greenery in the design of balconies has the potential to significantly impact those who experience the greenery's well-being. In such balconies, people feel happier, satisfied, connected to others, more independent, and that they have the ability to do something successfully. Contrary to expectations, this study did not find a significant difference between well-being and different amount of greenery. It means that well-being can be improved even with a few pots and there is no need for substantial amount of greenery to observe that effect. Therefore, it can be suggested that it is possible to reduce the symptoms of low well-being with getting exposed to green spaces in balconies. The research findings is in line with previous studies in this area that suggest exposure to limited amount of greenery in indoor space has the potential to positively impact different aspects of individuals psycho-physiological health and well-being including better patterns of eye movement, blood pressure heart rate, perceived restorativeness, and cognitive performance (Saedi & Rice, 2022a; Saedi & Rice 2022b; Abraham et al., 2010). Also, this finding is consistent with other studies including Dzhambov (2021) who found that the students who spent most of their time at home during the COVID - 19 pandemic to have better mental health when got exposed to vegetation (Dzhambov et al., 2021). These findings are also in line with earlier observations, which showed that a high percentage of dwellers asserted the importance of having a balcony in an apartment and its far-reaching impact on boosting mental health (Molaei, Hashempour, & Tang, 2022). In this research, it was shown that the greenery on the balcony has an effective relationship with the increasing tendency of people to have social connections, which is consistent with that of Huang (2006) who found that space design and the existence of greenery and plants can have an important role in increasing social interaction (Huang, 2006).Another research shows that indoor and outdoor greenery connected with fewer depressive symptoms during COVID-19 lock downs while gender, education, and income did not modify relationships between green spaces and depressive symptoms (Zhang et al., 2023).

Moreover, in this research no significant correlations were recorded between greenery and different ages or gender. This result is aligned with Khaledi (2022) who found that the use of green spaces and the rate of depression and anxiety are the same among males and females and also at different ages(Khaledi, Faizi, & Khakzand, 2022). This study supports evidence from research on students in India during COVID–19 to evaluate built environment attributes that found gender to have no significant associations with mental health(Asim, Chani, & Shree, 2021). The present result, is aligns with a prior study (Corley et al., 2021) which indicated that gender doesn't significantly influence how gardeners and non-gardeners perceive garden use and mental well-being among the elderly.

5. *Conclusion*

The outcomes of this study revealed that interaction with natural green elements in a balcony of a residential building has the potential to have a significant positive impact on individual's perception of their positive health and overall well-being. Residents who spent their time on the versions of the balcony with vegetation experienced better reported well-being. The positive impacts were more pronounced in the version of the balcony with higher volume of vegetations. Those who experience more greenery reported to feel happier, more satisfied, more connected to others, a sense of autonomy, and having the ability to perform tasks successfully which leads to higher perceived well-being. Also, the results showed that individuals could experience a better perceived well-being impact of natural greenery even when interacting with those elements in a VR environment with elements resembling natural vegetation.

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